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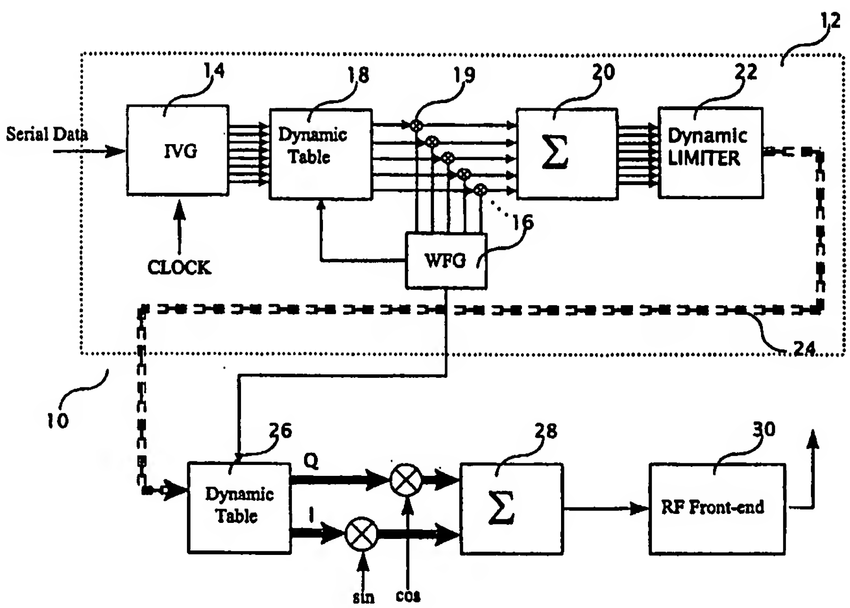

(57) Abstract

A coding and modulating system including a combined modulator/demodulator and spreading/despreading mechanism. In particular, a coding and modulating system wherein the combined modulator/demodulator and spreading/despreading mechanism includes an information vector generator (IVG), a dynamic Table coupled to the output of the information vector generator, a multiplication block for receiving the output of the dynamic Table, a Walsh function generator (WFG) coupled to the multiplication block, a summation block coupled to the output of the multiplication block, and a dynamic limiter for limiting the output of the summation block.

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CODING AND MODULATING SYSTEM

FIELD OF THE INVENTION

The present invention relates to coding and modulating systems for telecommunications.

BACKGROUND OF THE INVENTION

Many coding and modulating systems are known in the telecommunications art. These include the QAM family, CDMA, the QPSK family, among others.

For example, conventional CDMA systems include a modulator and a spreading mechanism. The modulator modulates the information and the spreading mechanism is connected to a PN code generator. In conventional CDMA systems, the spreading mechanism is a simple BPSK (binary shift keying) modulation device, whose efficiency is low. In order to differentiate between users, conventional CDMA systems assign a different PN code to each one of the users.

The receiver includes a despreader and a demodulator. The despreader must be synchronized first, then the demodulator is synchronized. If the despreader is not synchronized, it is impossible to synchronize the demodulator. This leads to a low efficiency differential modulation scheme in order to permit efficient synchronization.

It is an object of the invention to increase the efficiency of the spreading system. This is accomplished by combining the modulator and spreader into one block (referred to hereinbelow as a spreadulator). This increases the number of bits per second per Hertz so that a larger quantity of information can be transmitted in the same bandwidth.

SUMMARY OF THE INVENTION

According to the present invention, there is provided a coding and modulating system including a combined modulator/demodulator and spreading/despreading mechanism (spreadulator). The spreadulator preferably includes an information vector generator (IVG), a dynamic Table coupled to the output of the information vector generator, a multiplication block coupled to the output of the dynamic Table, a Walsh function generator (WFG) coupled to the multiplication block, a summation block coupled to the

output of the multiplication block, and a dynamic limiter for limiting the output of the summation block.

According to a preferred embodiment of the invention, there is provided a coding and modulating system including a transmitting unit including: a spreadulator for modulating and spreading input data including an information vector generator (IVG), a dynamic Table coupled to the output of the information vector generator, a multiplication block coupled to the output of said dynamic Table, a Walsh function generator (WFG) coupled to the multiplication block, a summation block coupled to the output of the multiplication block, and a dynamic limiter for limiting the output of the summation block; a second dynamic table coupled via a bus to the dynamic limiter for converting input signals to I and Q buses including a multiplier where the signals are multiplied by coherent sin and cosin waveforms, a summation element, and an RF front-end.

Further according to a preferred embodiment, the coding and modulating system further includes a receiving unit including: a front end for receiving transmitted signals, a multiplier for multiplying the received signals by sin and cosine coherent waveforms, an Analog to Digital (A/D) converter, an inverse dynamic table arranged to receive the multiplied digital signals, the inverse dynamic table being the inverse of the second transmitting dynamic table, a TelesciCOM fast transform (TFT) unit for transforming the input signals to a Walsh function spectrum, a management block for synchronizing the output Walsh function spectrum, a second inverse dynamic table which is the inverse of the spreadulator dynamic table, and an inverse information vector generator which is the inverse of the transmitting information generator for generating output signals substantially identical to the input signals in the transmitting unit.

According to one embodiment of the invention, the management block includes a threshold detector for dispersed noise of each information block, a comparator for comparing the detected dispersed noise with the average noise dispersion level so as to detect a minimum noise dispersion level, a phase lock loop to integrate several information blocks, and means for providing a synchronization pulse to the fast transform unit.

According to one embodiment of the invention the TFT unit includes a multiple channel butterfly Walsh function correlation block.

Further according to an embodiment of the invention, the management block detects a minimum noise dispersion level according to the formulae:

$$\sum_{i=0}^{n-1} \frac{|Ni|}{n} = \overline{N}$$
$$\sum_{i=0}^{n-1} |Ni - \overline{N}| = \delta$$

wherein N is the noise dispersion , N bar is the average noise level, and δ is the minimum noise dispersion level.

There is also provided in accordance with the present invention a method of coding and modulating for radio telecommunication including the steps of: modulating input data in an information vector generator in a spreadulator, spreading the input data using a Walsh function generator in the spreadulator, summing the output in a summation block, limiting the output of the summation block in a dynamic limiter, converting the limited signals to I and Q buses in a dynamic table coupled via a bus to the dynamic limiter, multiplying the signals by sin and cosin coherent waveforms, summing the multiplied signals, and transmitting the sum.

Further according to a preferred embodiment, the method further includes receiving the transmitted signals in a receiving unit, multiplying the received signals by coherent waveforms in a multiplier, converting analog signals to digital signals, converting the limited signals from I and Q buses in an inverse dynamic table, the inverse dynamic table being the inverse of the transmitting dynamic table, transforming the input signals to a Walsh function spectrum in a fast transform unit, synchronizing the output Walsh function spectrum in a management block, and generating output signals substantially identical to the input signals in the transmitting unit in an inverse information vector generator which is the inverse of the transmitting information generator.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be further understood and appreciated from the following detailed description taken in conjunction with the drawings in which:

Fig. 1 is a schematic illustration of a transmitting unit according to one embodiment of the invention; and

Fig. 2 is a schematic illustration of a receiving unit according to one embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to a multilevel spreading system having very high efficiency which is capable of easily synchronizing in the receiving unit, without losing any energy, even in a noisy environment, unlike conventional systems where resources must be diverted for synchronization. The use of a combined modulator/demodulator and spreading/ despreading mechanism (spreadulator) means that we can easily synchronize the receiver and easily recover information. It is a property of the invention that, unlike conventional CDMA, it can reallocate processing gain from unactivated users to activated users.

The invention uses a family of Walsh functions in such a way that we first generate the whole set of functions in one block. Looking now at Fig. 1, there is shown a schematic illustration of a transmitting unit 10 according to the invention including a combined modulator/demodulator and spreader/despreader (spreadulator 12) according to the invention. Input serial bit information is transferred to a symbol by an information vector generator 14 in spreadulator 12, which generates a vector of bits. Each one of the output bits is multiplied by the series of Walsh functions. The information vector generator (IVG) 14 is a block whose input is at least one user serial bit or several users (i.e., multi-channel serial data) and the output is an information vector. In the case of one user, IVG 14 copies each bit to all of the vector.

The output of IVG 14 is input to a first dynamic table 18. Dynamic table 18 may be a dynamic permutation table or any other selected table. The data output from the dynamic table 18 is input to a multiplication block 19. The system of the present invention uses a Walsh function generator 16 with series of functions. The data from dynamic table 18 is multiplied by the output of Walsh function generator 16 in multiplication block 19: the first bit XOR with the first Walsh function, the second bit XOR with the second Walsh function, and so on. It will be appreciated that the level of modulation is unlimited, depending only on the selected set of Walsh functions. Any desired set of Walsh functions can be used, preferably from 16 and above, merely by using more gates and adding more gain.

According to one embodiment of the invention, Walsh function generator 16 is coupled to dynamic table 18 and is arranged to produce a high order Walsh function in order to utilize a selected table from among many different tables in dynamic table 18.

The information output by multiplication block 19 goes to a summation block 20.

The ouput goes to a dynamic limiter 22 which cuts over-shooting and also takes very low signals and stretches them into zero, reducing the dynamic band. The energy above a certain level is not transmitted and lower than certain level is also cut off. While this reduces by a small amount the amount of information transmitted, this information can easily be recovered in the receiver. The system transfers energy from unused levels into the most used levels, thereby increasing average bit energy.

From the dynamic limiter 22 in spreadulator 12, the signals go via a bus 24 to a second dynamic table 26, which converts them into I and Q buses. It is a property of dynamic table 26 that is can easily incorporate security codes and differentiate among different users. From the I and Q buses, the signals are multiplied by coherent sin and cosin waveforms, summed in a summation block 28, and transmitted to the air via a conventional RF transmitting front end 30.

In the receiver, shown in Fig. 2, is an RF front end 32. The received I and Q signals are multiplied by coherent sin and cosin waveforms in a multiplier 34, then preferably to an A/D converter 36, which can alternatively be located before the multiplier. The resulting digital signals go to an inverse dynamic table 38, which is the inverse of the second dynamic table in the transmitting unit. The inverse dynamic table 38 converts the multiplied digital signals to a symbol stream. The output goes to a TelesciCom fast transform (TFT) unit 40 for fast transformation of the Walsh function. TFT unit 40 includes a multiple channel butterfly Walsh function correlation block, and serves to transform the input signals to a Walsh function spectrum. In essence, it is a very efficient multilevel/ multichannel correlator. The output of TFT 40 goes to a management block 42, which performs synchronization. It is a property of the invention that instead of measuring maximum bit energy, it measures minimum dispersion of noise at each particular time. Thus, management block 42 includes a threshold detector for the dispersed noise for each information block. The system compares the average noise dispersion level with the minimum noise dispersion level. When the minimum dispersed value of the noise is significantly less than the mean energy of the noise, that is the synchronization point. This can be found by using the formulae:

$$\sum_{i=0}^{n-1} \frac{|Ni|}{n} = \overline{N}$$

$$\sum_{i=0}^{n-1} \left| Ni - \overline{N} \right| = \delta$$

wherein N is the noise dispersion , N bar is the average noise level, and δ is the minimum noise dispersion level. The management block 42 includes a phase lock loop in order to integrate several information blocks so as to achieve better noise immunity.

The management block 42 provides a synchronization pulse to TFT 40 and, at the moment of synchronization, the information in TFT 40 is loaded into a second inverse dynamic table 44. Second inverse dynamic table 44 is the inverse of the dynamic table 18 in spreadulator 12 in the transmitting unit. From inverse dynamic table 44, the information is input into an inverse information vector generator 46 which is the inverse of IVG 14 in the transmitter. Inverse IVG 46 in the receiving unit outputs serial information which corresponds to the information as originally input.

It will be appreciated that the invention is not limited to what has been described hereinabove merely by way of example. Rather, the invention is limited solely by the claims which follow.

CLAIMS

1. A coding and modulating system comprising a combined modulator/demodulator and spreading/despreading mechanism.

2. The coding and modulating system according to claim 1, wherein said combined modulator/demodulator and spreading/despreading mechanism includes:

 an information vector generator (IVG);

 a dynamic Table coupled to the output of said information vector generator;

 a multiplication block for receiving the output of said dynamic Table;

 a Walsh function generator (WFG) coupled to said multiplication block;

 a summation block coupled to the output of said multiplication block; and

 a dynamic limiter for limiting the output of the summation block.

3. A coding and modulating system comprising a transmitting unit including:

a spreadulator including:

 an information vector generator;

 a dynamic Table coupled to the output of said information vector generator for preparing data for multiplication;

 a Walsh function generator (WFG);

 a multiplication block coupled to said dynamic Table and to said Walsh function generator;

 a summation block coupled to the output of said multiplication block; and

 a dynamic limiter for limiting the output of said summation block;

a second dynamic table coupled via a bus to the dynamic limiter for converting input signals to I and Q buses including a multiplier where the signals are multiplied by coherent sin and cosin waveforms;

a summation element; and

an RF front-end.

4. The coding and modulating system according to claim 3, further comprising a

receiving unit comprising:

a front end for receiving transmitted signals,

a multiplier for multiplying the received signals by coherent sin and cosin waveforms;

an Analog to Digital (A/D) converter;

an inverse dynamic table arranged to receive the multiplied digital signals and convert them to a symbol stream, the inverse dynamic table being the inverse of the second transmitting dynamic table;

a fast transform unit for transforming the signals from said dynamic table to a Walsh function spectrum;

a management block for synchronizing the output Walsh function spectrum;

a second inverse dynamic table, the inverse of the spreadulator dynamic table in the transmitting unit, for converting the output Walsh function spectrum; and

an inverse information vector generator which is the inverse of the transmitting information generator for generating output signals substantially identical to the original input signals in the transmitting unit.

5. The coding and modulating system of claim 4, wherein said management block includes:

a threshold detector for dispersed noise of each information block;

a comparator for comparing the detected dispersed noise with the average noise dispersion level so as to detect a minimum noise dispersion level;

a phase lock loop to integrate several information blocks; and

means for providing a synchronization pulse to said fast transform unit.

6. The coding and modulating system of either of claims 4 and 5, wherein said management block detects a minimum noise dispersion level according to the formulae:

$$\sum_{i=0}^{n-1} \frac{|Ni|}{n} = \overline{N}$$

$$\sum_{i=0}^{n-1} \left| Ni - \overline{N} \right| = \delta$$

wherein N is the noise dispersion , N bar is the average noise level, and δ is the minimum noise dispersion level.

7. The coding and modulating system of any of claims 4 to 6, wherein said fast transform unit includes a multiple channel butterfly Walsh function correlation block.

8. The coding and modulating system of any of claims 2 to 7, wherein said Walsh function generator is coupled to said spreadulator dynamic table and is arranged to produce a high order Walsh function in order to selectably utilize any selected table in said dynamic table.

9. A method of coding and modulating for radio telecommunication comprising the steps of:

modulating input data in an information vector generator in a spreadulator;

spreading the input data using a Walsh function generator in the spreadulator;

summing the output of the information vector generator multiplied by a set of Walsh function ouput from said Walsh function generator in a summation block;

limiting the output of said summation block in a dynamic limiter;

converting the limited signals to I and Q buses in a second dynamic table coupled via a bus to said dynamic limiter;

multiplying the signals by coherent sin and cosin waveforms;

summing the multiplied signals; and

transmitting the sum.

10. The method according to claim 9, and further comprising the steps of:

receiving the transmitted signals in a receiving unit;

multiplying the received signals by coherent sin and cosin waveforms in a multiplier;

converting analog signals to digital signals;

receiving the multiplied digital signals in an inverse dynamic table, the inverse dynamic table being the inverse of the second transmitting dynamic table;

transforming the input signals to a Walsh function spectrum in a fast transform unit;

synchronizing the output Walsh function spectrum in a management block;

converting said output Walsh function spectrum to symbols in a second inverse dynamic table, said second inverse dynamic table being the inverse of the dynamic table in

the combined modulator/demodulator and spreading/despreading mechanism in said transmitting unit; and

generating output signals substantially identical to the input signals in the transmitting unit in an inverse information vector generator which is the inverse of the transmitting information generator.

11. The method according to claim 10, wherein said management block synchronizes the output Walsh function spectrum in accordance with the following formulae:

$$\sum_{i=0}^{n-1} \frac{|Ni|}{n} = \overline{N}$$
$$\sum_{i=0}^{n-1} \left| Ni - \overline{N} \right| = \delta$$

wherein N is the noise dispersion , N bar is the average noise level, and δ is the minimum noise dispersion level.

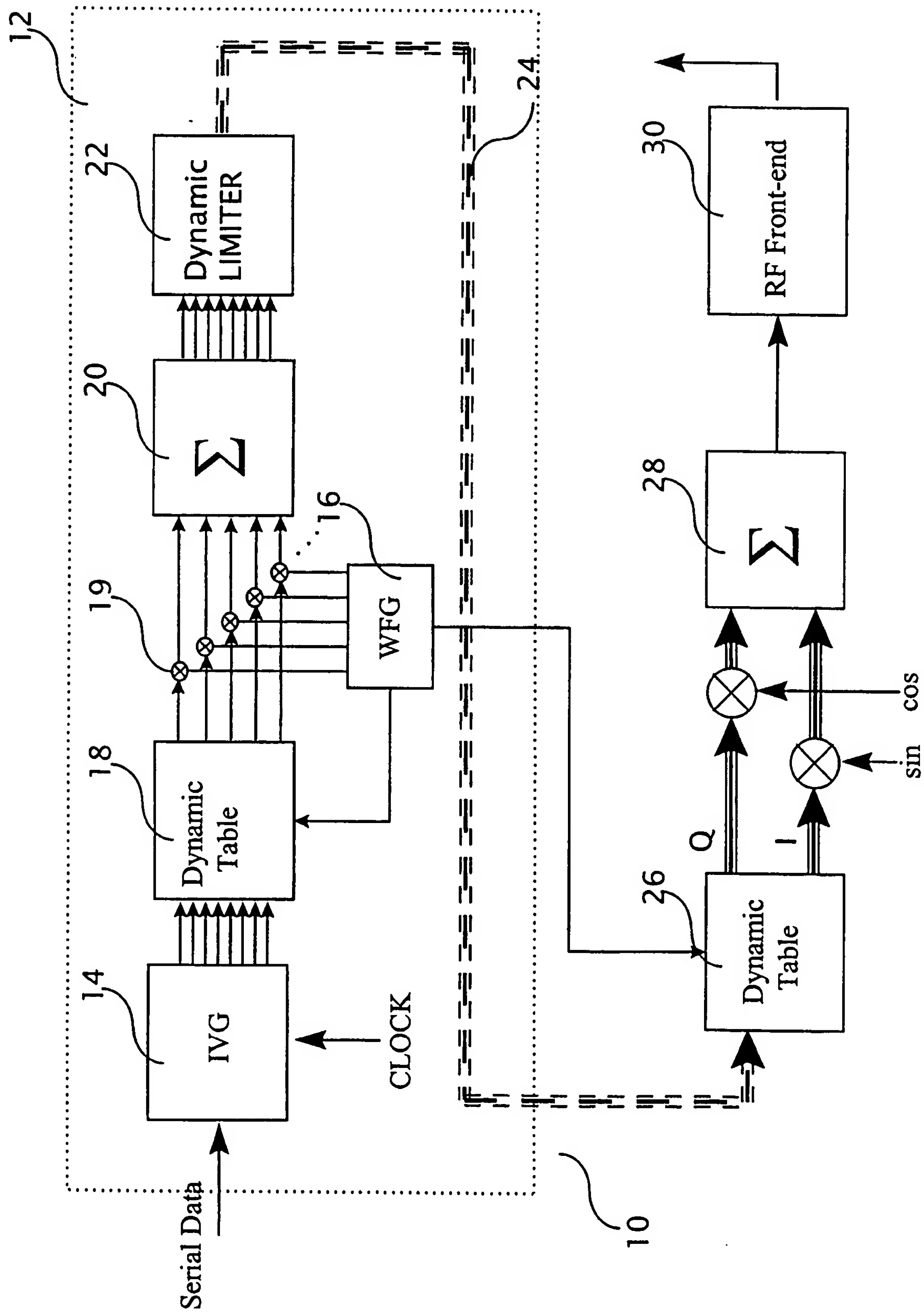
12
14
IVG
CLOCK
Serial Data
18
Dynamic Table
19
16
WFG
20
Σ
22
Dynamic LIMITER
24
10
26
Dynamic Table
Q
I
cos
sin
28
Σ
30
RF Front-end

Fig. 1

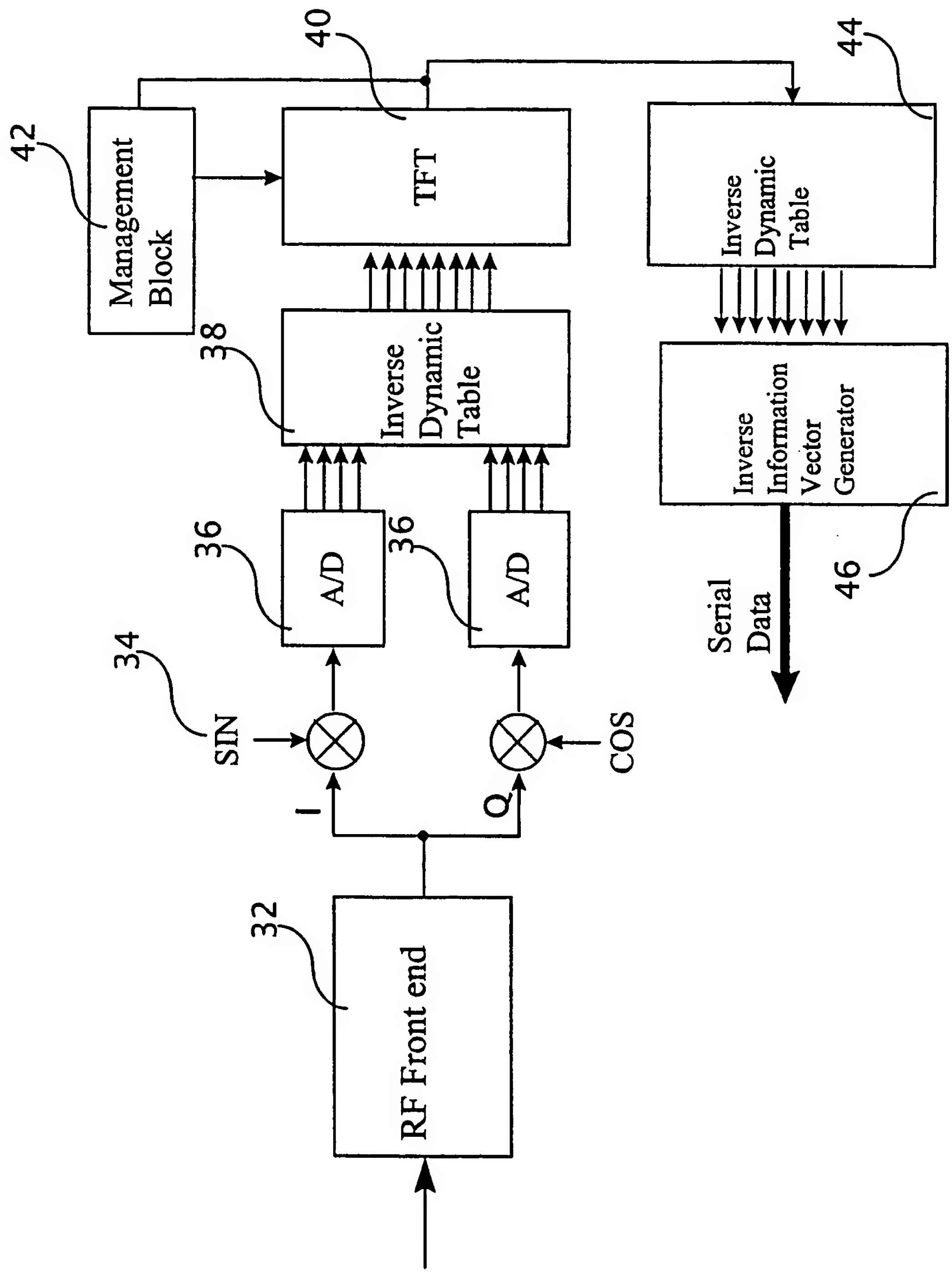
42
Management Block
40
TFT
44
Inverse Dynamic Table
38
Inverse Dynamic Table
Inverse Information Vector Generator
46
36
A/D
36
A/D
Serial Data
34
SIN
COS
I
Q
32
RF Front end

Fig. 2

INTERNATIONAL SEARCH REPORT

Interr nal Application No
PCT/IL 98/00478

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04J11/00 H04B1/707

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04J H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 92 17012 A (MOTOROLA INC) 1 October 1992 see abstract	1,2,8
A	see page 9, line 5 - page 11, line 9 ---	3,9
X	US 5 373 502 A (TURBAN KARL-ALBERT) 13 December 1994 see abstract see column 4, line 15 - column 5, line 10 see column 6, line 6 - line 31	1
A	see column 6, line 42 - column 7, line 30 ---	2,3,9
X	WO 96 27250 A (QUALCOMM INC) 6 September 1996 see abstract	1
A	see page 7, line 23 - page 14, line 2 --- -/--	2,3,9

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
18 February 1999	26/02/1999

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 619 526 A (KIM JIN U ET AL) 8 April 1997 see abstract see column 4, line 67 - column 5, line 7 -----	2,3,9

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/IL 98/00478

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9217012 A	01-10-1992	CA 2077332 A,C	14-09-1992
		DE 69227350 D	26-11-1998
		EP 0533887 A	31-03-1993
		IL 101099 A	26-05-1995
		JP 2601030 B	16-04-1997
		KR 9600353 B	05-01-1996
		SG 47496 A	17-04-1998
		US 5235614 A	10-08-1993
US 5373502 A	13-12-1994	DE 4210305 A	07-10-1993
		CA 2092874 A	01-10-1993
		EP 0567771 A	03-11-1993
		FI 931409 A	01-10-1993
WO 9627250 A	06-09-1996	AU 5028296 A	18-09-1996
		CA 2213998 A	06-09-1996
		EP 0812500 A	17-12-1997
		US 5777990 A	07-07-1998
		ZA 9601025 A	16-07-1996
US 5619526 A	08-04-1997	KR 9603102 B	04-03-1996